INTERIM REPORT - UPPER OTTAWA STREET LANDFILL SITE STUDY, REFERENCE PAPER 20 : INVESTIGATION OF GROUNDWATER CONTAMINATION ...

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AN INVESTIGATION OF GROUNDWATER CONTAMINATION AT THE UPPER OTTAWA STREET LANDFILL, HAMILTON

EC Committee

A Contract Proposal

AN INVESTIGATION OF GROUNDWATER CONTAMINATION AT THE UPPER OTTAWA STREET LANDFILL, HAMILTON

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Submitted to:

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INTRODUCTION

Investigations by Gartner Lee Associates Limited and sampling of an experimental groundwater monitoring device that was installed by the University of Waterloo has established that a plume of contaminated groundwater exists in the bedrock at the Upper Ottawa Street landfill site. The occurrence of a plume was not surprising because water from rain and snowmelt has, for many years, infiltrated through the landfill and because the bedrock and the thin layer of glacial overburden beneath the landfill are permeable. It has been established that some of the groundwater samples obtained from the Gartner Lee and University of Waterloo monitoring points contained chloride and total dissolved organic carbon at concentration levels that are much higher than is usually observed in plumes at normal municipal landfills.

The number of devices in the groundwater monitoring network that currently exists at the site is insufficient for determinations of the depth of penetration in the bedrock and the areal extent of the contaminant plume. The primary purposes of the monitoring program outlined in this proposal are to delineate the spatial distribution of the plume and to determine the chemical composition of the plume. We expect that the data that will be acquired during the monitoring program will provide a basis for the development of some preliminary predictions regarding the behavior of the plume in future years or decades.

Although the program of monitoring proposed herein covers a two-year period, emphasis in this proposal is on the first year. The nature of the investigations that will be performed in the second year will depend to a major degree on the results obtained in the first year.

METHODS AND SCOPE

The main pathway for subsurface migration of contaminants from the landfill is the network of fractures in the bedrock. It is reasonable to expect that this network is complex. The strategy for monitoring will be based on the premise that horizontal, or near-horizontal fractures associated with bedding planes in the bedrock are the dominant avenues for off-site contaminant migration. Monitoring of the groundwater system will therefore be accomplished primarily by sampling in vertical boreholes. Considerable variability of contaminant concentrations with depth is expected (i.e. different concentrations in different fractures). The groundwater monitoring devices should therefore be capable of providing samples from several depths in each borehole. The monitoring strategy will therefore consist of multilevel monitoring in vertical boreholes at numerous sites in the vicinity of the landfill.

Monitoring at different levels at each site will be accomplished by installing a multilevel monitoring device in a single borehole at each site. The device will consist of a bundle of tubes in a PCV casing. Each tube will protrude through the casing at a different depth level so that the various tubes will enable water to be pumped from the hole at different levels. Each sampling level will be sealed above and below by means of packers. The packers will be composed of an expandible gel inside a flexible membrane or an injected mass of epoxy. The gel will form the seal as it expands due to contact with water. The epoxy will form a seal when it is pressure injected into the packers.

In November, 1981, a multilevel monitoring device of this type (with gel seals) was successfully installed in the bedrock at one site near the landfill. The device has performed in accordance with its design objectives and therefore it is our intention to use similar devices for most of the ground-

water monitoring that we intend to conduct at the site. Our objective is to have a capability for acquiring groundwater samples from a minimum of about five depth levels and a maximum of about ten depth levels at each monitoring site. The exact number of sampling levels that will be developed at each site will depend on the specific hydrogeological conditions at each site. We expect that at most sites one borehole will provide for an adequate number of sampling levels. At some sites it will probably be necessary to use two boreholes, one at shallow depth and a second at greater depth.

The network of multilevel monitoring devices will be installed in several phases. Each phase will consist of a program of drilling and subsequent sampling and chemical analyses. The results from the first phase will serve as the main basis for design of the second phase, the results of the first two phases for the design of the third, and so on. The lateral and vertical extent of the zone of contamination in the bedrock will therefore be determined largely by an iterative procedure with the overall strategy becoming more refined as our knowledge of the hydrogeological conditions gradually improves.

During each phase multilevel monitoring devices will be installed at a number of sites (between 6 - 12). The devices will be pumped on two or three occasions in subsequent weeks to minimize the disturbance to the hydrochemical system caused by the drilling. The devices will then be sampled for analysis of a series of diagnostic parameters. The diagnostic parameters will provide an indication of the presence or absence of landfill-derived contaminants in the water and a general indication of the degree of severity of contamination. The suite of diagnostic parameters will include pH, electrical conductance, chloride, sulfate, total dissolved organic carbon and a scan for volatile organics. These parameters are appropriate because the analyses can be

obtained quickly and because small-volume water samples are adequate for the analyses. Depending on the results obtained in the first monitoring phase, this suite may be enlarged or contracted to obtain a better capability for identification of landfill-impacted water.

In each phase, samples from several of the monitoring points (i.e. one or two points per site from a few sites) will be analysed for a relatively comprehensive list of constituents, including the major ions, nitrogen species, and some heavy metals and metalloids, and a more detailed evaluation of the organic compounds in the water. The results of these analyses will provide a basis for comparing the severity of the groundwater contamination at the Upper Ottawa Street site with other landfills in Ontario from which detailed hydrochemical data have been obtained and for appraisal of the degree of hazard that the contaminated zone may represent.

Most of the monitoring devices will be installed at locations where there is a reasonable possibility that contaminated groundwater will occur. A few will be placed at sites where there is no possibility of landfill-derived contaminants occurring. These monitoring sites will be used to establish the background composition of groundwater in the bedrock.

Most of the groundwater monitoring devices will be installed at depths less than about 40 m because it is likely that most of the contaminated zone occurs at depths shallower than 40 m. At a few sites, however, monitoring devices will be installed in holes to depths as great as 100 m. A few deep holes will be drilled near the landfill in the early phases of the investigation in order to determine the depth to which landfill leachate has moved in the bedrock. If this can be established early in the investigation, delineation of the contaminant plume away from the landfill will probably be accomplished more readily.

We are unsure of our ability to install multilevel sampling devices in boreholes deeper than about 40 m. We may find that it will be necessary to use conventional piezometers at sites where deeper monitoring is desired. After the first one or two phases, the results may indicate that angle boreholes will be desirable at a few locations in order to evaluate the effects of non-horizontal fractures.

At each site where a monitoring device is installed, a bedrock core will be taken. The cores will provide an indication of the depth levels at which fractures occur. Water-levels will be measured by lowering an electric probe into each of the tubes in the multilevel monitoring devices. Water-level response tests will be made in the tubes to obtain estimates of the hydraulic conductivity of the various vertical intervals in the boreholes. Packer-injection tests will not be made in the boreholes prior to installation of the multilevel sampling devices.

In a few representative boreholes, borehole dilution tests will be conducted in order to obtain direct estimates of the rate of groundwater flow at depth levels where contaminant concentrations are particularly high. These tests will probably not be conducted until the second year of the investigation. In the first year, flow rates will be obtained using the conventional Darcy approach.

SCHEDULE AND REPORT CONTENT: YEAR 1

We plan to conduct four phases of drilling and sampling during the first year of the two-year investigation. Each phase will take about seven or eight weeks, which will include two to three weeks of drilling for bedrock coring and installation of multilevel samplers and piezometers and three or

four weeks for pumping, sampling, analysis and preliminary data interpretation. The four phases will run in sequence from early April to November. The winter months, December to March, will be used for data interpretation and report preparation and for special studies of some of the organic components in the contaminated groundwater.

Emphasis in the report for the Year I investigation will be on the presentation of the results of the drilling and chemical analyses in the form of maps and cross sections that will display the geology and the patterns of contamination in the groundwater system. Maps and cross sections will also be used to display hydraulic-head data and interpretations of directions of groundwater flow. Preliminary estimates of the rates of groundwater in the main zones of contamination will be made from the hydraulic-head and hydraulic conductivity data.

The report will also include comparisons of the groundwater chemistry at the Upper Ottawa Street landfill site with data from other landfills in Ontario for which detailed information is available. It is important that the impact of the Upper Ottawa Street landfill on groundwater not be taken out of context when the results are described for the general public, and when possibilities for remedial action are being considered by government agencies.

CHEMICAL ANALYSES

Analyses for routine parameters such as pH, electrical conductance, chloride, sulfate and total dissolved organic carbon will be done in the Geochemistry Laboratory at the University of Waterloo. In many cases, pH measurements will be made in the field immediately after the water samples are collected.

It is our preference that the comprehensive chemical analyses for inorganic constituents in a representative group of groundwater samples be conducted by the Water Quality Laboratory (Toronto) of the Ministry of the Environment. This laboratory has conducted the inorganic analyses of groundwater samples from the other landfills in Ontario that we are investigating. We have confidence in this laboratory for this type of work and we wish to maintain consistency in the analyses in order to have a reliable basis for comparison between sites.

The analyses of organic constituents in the groundwater samples will be accomplished using the analytical services of several laboratories, including a laboratory in Division of Environmental Engineering and Science at Stanford University, the Organic Geochemistry Laboratory at the University of Waterloo, and Mann Testing Laboratories in Toronto. Co-operative research involving Waterloo and Stanford pertaining to the occurrence and movement of dissolved organic compounds in zones of contaminated groundwater at several landfills in Ontario, which has been underway since November, 1981, has provided us with access on a chargeable basis to the analytical services of the laboratory at Stanford University that specializes in the analysis of organic compounds in groundwater. This laboratory is currently analysing for organic compounds in samples of groundwater obtained from three Ontario landfills that we are studying with financial support provided by the Ontario Lottery Fund and by the U.S.E.P.A.

YEAR 2

It will not be possible to prepare a detailed plan for investigations in Year 2 until the results for the first half or two-thirds of Year 1 are evaluated. It is likely that many more multilevel monitoring devices will be installed during Year 2. We expect that these installations will be concentrated in

local areas where specific problems are identified during Year 1. It is possible that during Year 1 areas where landfill-derived contaminants are migrating from the groundwater zone into the surface environment via small springs or soil seepage will be detected. The nature of these discharge zones would then be a focus for investigations in Year 2.

In Year 1 the investigations will deal almost entirely with contaminant occurrence in the groundwater. In Year 2 there will be continued emphasis on contaminants in the groundwater, but there will also be investigations directed towards contaminant occurrence in the rock. It is reasonable to expect that some contaminants are adsorbed on the surfaces of the fractures and that some contaminants slowly enter the pore spaces in the interior of the rock masses (i.e. into the rock matrix). This entry into the rock matrix will occur by molecular diffusion through the channels provided by interconnected pores in the rock matrix. The occurrence of contaminants adsorbed on the fractures and diffused in the matrix may be important because, in future years, these contaminants can re-enter the flowing groundwater and then eventually enter the biosphere.

The most reasonable remedial action that could be undertaken at the Upper Ottawa Street landfill would be the installation of an engineered cover on the landfill for the purpose of reducing the entry of water into the landfill to a very low annual rate. If a cover is used to prevent infiltration through the refuse above the water table and if other hydrologic control measures are used to insure that the water table is below the bottom of the refuse so that groundwater does not flow through the landfill, the landfill will no longer be a contributor of contaminants to the groundwater zone. If this condition is achieved, the groundwater system will gradually undergo a decline in total contaminant load and a decline in contaminant concentrations. In other words, the zone of contaminated groundwater will be diluted because of dispersive mixing and the total load will decline because of discharge of contaminated

groundwater to the surface and possibly because of biodegradation of organic compounds. As the decline occurs, some of the contaminants that are adsorbed on the fracture and diffused in the matrix will re-enter the groundwater flow system. This re-entry will cause the overall "flush-out" rate to be slower than would otherwise be the case.

Whereas the investigations in Year 1 will be directed almost entirely towards the task of mapping the zone of contamination in the bedrock, we expect that the Year 2 investigations can at least in part be directed towards topics related to assessment of the future behavior of the zone of contamination.

PROVISION OF SERVICES TO THE WATERLOO GROUP

The budget outlined on the following pages is based on the assumption that several necessary services will be provided "free-of-charge" by other groups involved in the overall site study. These services are as follows:

1. Acquisition of permissions from land owners for drill rig access to property, arrangements for the leaving of monitoring devices in boreholes on private and public property, and permission for periodic access to the devices for sampling and water-level monitoring.

2. Liaison with local residents and the press: the University of Waterloo group will be pleased to talk to local residents and, from time to time, make slide-show-type presentations. We would prefer, however, not to be involved in the day to day liaison with residents or in the formalities of arranging for information sessions with groups representing the local residents. We would prefer that all arrangements for interviews with the press and other media people be made through a central office that will manage these situations.

3. Precautions for health safety during drilling and sampling. The

Waterloo group will be responsible for adhering to the normal precautions for safety during drilling operations. We do not have the competence, however, to make decisions with regard to safety precautions relating to possible health effects of inhalation of fumes from boreholes and of fumes from water samples or with regard to the effects of skin contact with contaminated water from boreholes. In our previous studies of landfills we have taken no special precautions.

Because the Upper Ottawa Street landfill has received a variety of toxic industrial wastes, we think that a more formal approach to health safety is necessary. We ask that directions regarding health safety precautions in the field be provided to us and that fumes near boreholes be periodically analysed.

4. Analytical services for determination inorganic constituents in groundwater samples. We want to submit a group of groundwater samples to the MOE Toronto Laboratory for analysis of major ions, and about twelve other inorganic constituents such as some transition metals, heavy metals, metalloids and nitrogen species. The total number of samples in Year 1 will be about 60. We prefer to use the MOE labs because our previous experience with this lab has been very favourable and because we wish to maintain consistency of results between the various landfills that we are investigating.